

## An Algorithm Applied to the Design of Centering and Fixing Devices

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### ABSTRACT

*Making use of hydro-plastic centering and fixing devices significantly increases the accuracy of the mechanical machining of even mild material pieces. The paper describes the program which based on the input data can size and finally provide the assembly drawing of the hydro-plastic device.*

**Keywords:** devices, hydro-plastic.

### 1. Introduction

Centering and fixing the blank by means of mechanisms of prism, wrench, plunger, jaws, etc are often followed by non-uniform deformations of the base surfaces if not their total local destruction. That is why the centering accuracy decreases, fixing the thin walled blanks is difficult while fixing mild materials blanks is impossible. Such disadvantages are generally eliminated by using hydro-plastic centering and fixing mechanisms as the contact between mechanisms and blank is along the whole length of the base surface and not only on some limited areas. The hydro-plastic mechanisms feature very simple construction, low weight and high accuracy.

### 2. Calculation of the chuck collet

When the hydro-plastic devices are free, there is a clearance between the bore and spindle. For diameters up to 100 mm a tolerance of H7 is chosen for the bore, g7 for the spindle and f7 for larger diameters. The device rigidity and safety depend on the piston sealing accuracy. This requirement is met by using plastic materials (vinyl poly-chloride). This material is subject to Pascal principle on the uniform pressure distribution along all directions, it is almost incompressible to sealing and high pressures ( $3000 \cdot 10^4$  Pa), it can be even if there is a small clearance between the piston and the cylinder.

In spite of the operators of hydro-plastic mandrile being a little bit reluctant to use it, the experimental researches made it possible to plot

nomograms which significantly simplified the design process.

Fig 1 illustrate the construction formulas applied to hydro-plastic devices.

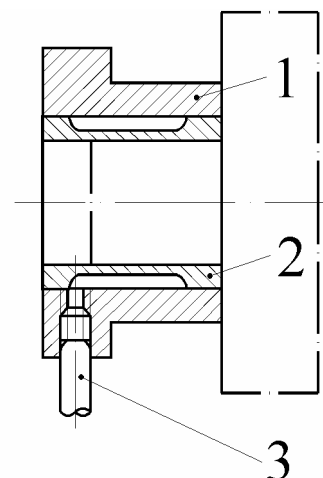
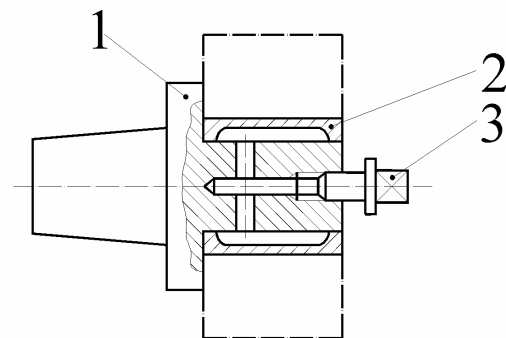


Fig. 1. Self-centred mandril

When designing a hydro-plastic device known parameters should be considered such as: the bore max. diameter and the max. torque produced by the cutting force (Fig.2).

$$M_r = \frac{F_z \cdot D_0}{2} \quad [N \cdot m]$$

where:

$F_z$  is the tangent to the cutting force

$D_0$  - external diameter of the blank being machined.

To ensure a proper tightening, a tightening moment equal to  $(1,3 \div 1,5)M_r$  is chosen while the axial force is

$$F_a = (1,3 \div 1,5)F_x$$

where  $F_x$  is the axial component of the cutting force.

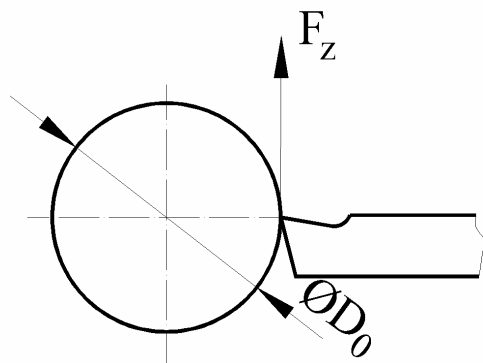


Fig. 2. Bushes strain in cutting time

The max axial force the device can bear under good machining conditions can be written as

$$F_x = \frac{F_a}{(1,3 \div 1,5)} = \frac{D \cdot p_0 \cdot f}{(1,3 \div 1,5)} \quad (1)$$

For  $f=0,2$  expression (1) is

$$F_x = (0,415 \div 0,485) \cdot D \cdot p_0 \quad (2)$$

The same holds for the friction torque

$$M_u = \frac{F_a \cdot D}{2} = \frac{\pi \cdot D \cdot p_0 \cdot f \cdot D}{2} = (1,3 \div 1,5)M_r$$

and mounting torque

$$M_r = \frac{D^2 \cdot p_0 \cdot f}{(2,6 \div 3)} = (0,31 \div 0,24)D^2 \cdot p_0 \quad (3)$$

To size the bush it is necessary to determine the pressure  $p_0$  which leads to an increase in the bush external diameter from  $D$  to  $D + \Delta$  (Fig. 3).

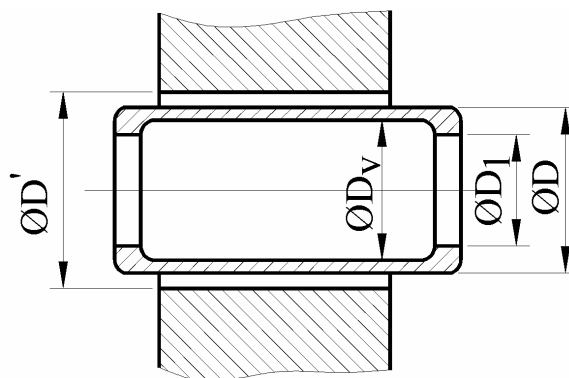


Fig. 3. The clearance between the bushes and workpiece

In fig 3  $D'$  denotes the blank internal diameter. The long bushes are calculated by means of thin-walled cylindrical vessels biaxially loaded

- tangentially  $\sigma_t = \frac{D \cdot p}{2g}$ ;

- axially  $\sigma_0 = \frac{\pi(D^2 - D_v^2)D}{4\pi D_s} = \frac{(D^2 - D_v^2)p}{4D_s}$ ,

where  $g$  is the bush wall diameter in the area to be expanded ;

$D$  – the bush external diameter;

$P$  – pressure  $P_a$  (MPa), by means of which the hydro-plastic acts upon the bush walls.

The bush internal diameter is determined for the situation presented in Fig 1 (item 1) by means of the relation

$$D_v = D - 2g - 2H.$$

Table 1 and 2 provides the calculation necessary to turn the hydro-plastic bush designing algorithm.

Table 1

Parameter	Short bushes
Deformation $\Delta$	$\Delta = (1-K) \frac{\sigma_k \cdot D}{c_l \cdot E} \left[ 1 - \varphi \left( \beta \frac{L}{2} \right) \right]$
Bush wall thickness, g	$g = \frac{(1-K) D^2 p}{2E\Delta} \left[ 1 - \varphi \left( \beta \frac{L}{2} \right) \right]$
Piston diameter	$d = 1,3\sqrt{D} \quad [mm]$
Calculation of the number of coils	$n = 0,604 \frac{L[\Delta D + 0,006H(D_v + H)]}{t \cdot D}$

Table 2

Parameter	Long bushes
Deformation $\Delta$	$\Delta = (1-K) \frac{\sigma_c \cdot D}{c_l \cdot E}$
Bush wall thickness, g	$g = \frac{(1-K) D^2 p}{2E\Delta}$
Piston diameter	$d = 1,8\sqrt{D} \quad [mm]$
Calculation of the number of coils	$n = 1,159 \frac{L[\Delta D + 0,006H(D_v + H)]}{t \cdot D}$

Since the tightening pressure is

$$p_0 = 4,61 \cdot 10^{11} \cdot \delta \sqrt{\frac{g^3}{D^3}} \quad [Pa],$$

and making the proper substitutions (2) and (3) we get:

$$p_x = (1,91 + 2,245)g \cdot \delta \sqrt{\frac{g}{D}} \cdot 10^{11} \quad [Pa];$$

$$M_r = (0,97 + 1,105)g \cdot \delta \sqrt{\frac{g}{D}} \cdot 10^{11} \quad [N \cdot m].$$

The piston stroke will be

$$l = t \cdot n.$$

The hydro-plastic fixing bushes are made from carbon steel (OSC7 STAS 1700/80) or alloyed steel (28TiMnCr12 STAS 791/80).

At its both ends the bush is provided with collars which are tightened to the mandrel body. That is why, for the calculation purpose, the bush is considered embedded at its ends.

### 3. The algorithm of the hydro-plastic device computer-aided design

A computing algorithm used to calculate the elements of a hydro-plastic fixing device is presented; the program is an AutoLISP which collects the data by means of a friendly interface featuring WINDOWS properties. The automatic programming of the elements is based on the execution drawing of the piece we want to fix/fasten.

Turning a problem such as the one approached in this paper into a programming language needs a number of stages.

*Analysis* – to examine the problem, make up the algorithm variants.

*Programming* – turning the previously defined algorithm into a programming language and testing it by means of test data.

*Implementation* – testing the program with real data, issuing a program user's documentation.

The AutoLISP program consists of four zones: the header zone; the declaration zone, the function explicit assessment zone; the main program zone.

The Header zone includes: the application title, explanations concerning the program objective; algorithm used to reach the objective.

The declaration zone is an optional but necessary zone. It is used to describe the types of data, variables, functions and constants.

In the function explicit assessment zone, the functions defined by users are explicitly described. Each function contains local, global, constant variables and a general computing block.

The global variables are memorized throughout the program running while the local variables are lost when leave their defining functions.

The size, of the piece to machine have been parametrized so that, for various values of the piece dimensions, different weights of that piece will be obtained. Each element was defined as functions which are successively appealed by the main program.

The zone of the main program contains a logic sequence of the subprograms (function procedures) predefined (contained within the language itself), defined by the user or defined in AutoCAD; the following logic succession is run: the main program zone, the work space initialization, selecting the dimensional element, subprogram.

Figure 4 illustrates the logic scheme block diagram of the CAD program for the hydro-plastic centering device.

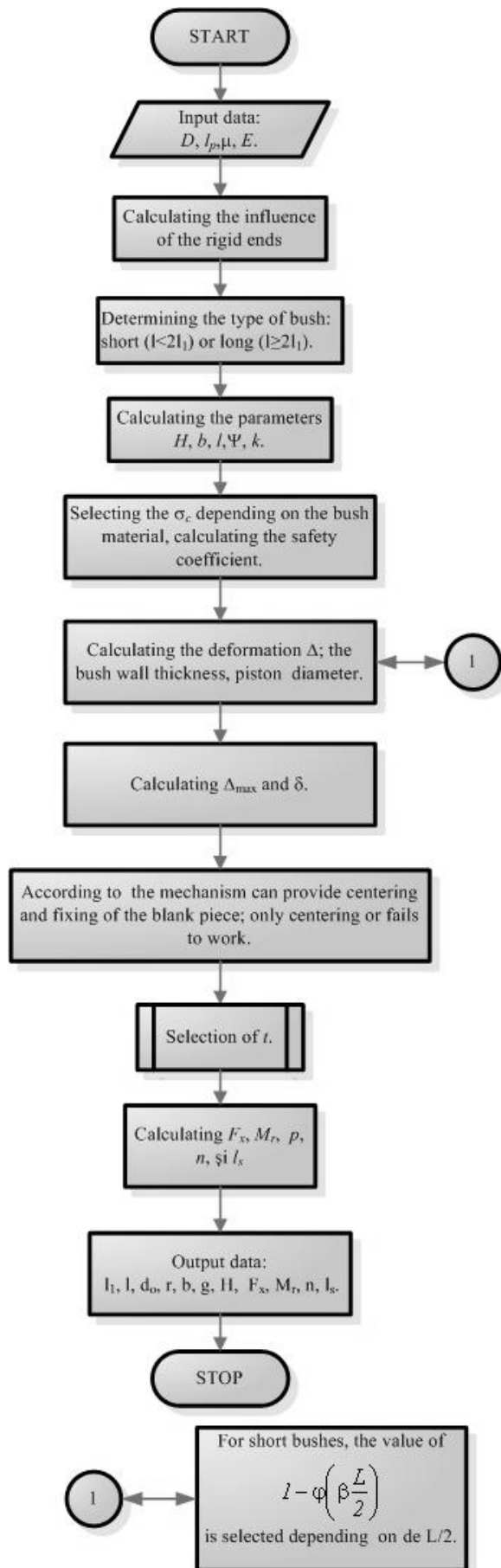


Fig. 4. The clearance between the bushes and workpiece

The program has a modular structure, each module mighting generate the drawing of execution of the selected component.

Let us consider the bore 48 H7 and the device diameter 48 g6. The max. torque, axial force and main dimensions of the device are required. The tightening length  $L_1 = 60$  [mm] the materials having the yielding point  $\sigma_c = 80000 \cdot 10^4$  [Pa] is chosen, the safety coefficient is 1.5.

Figures 5, 6, and 7 presented the drawings of executions of the elements what enter into the component of the device: cap screw, plunjer and chuck collet.

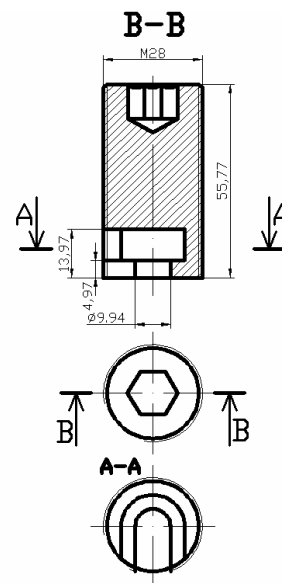


Fig. 5. Cap screw

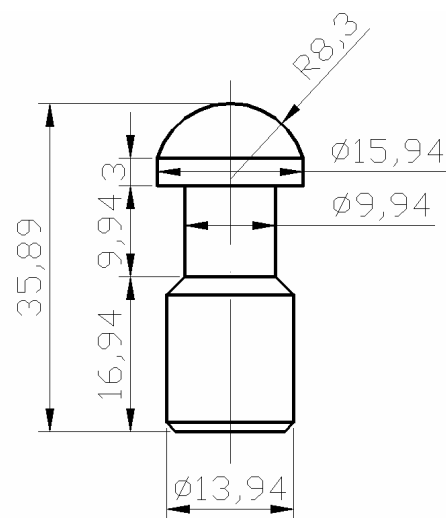


Fig. 6. Plunjer

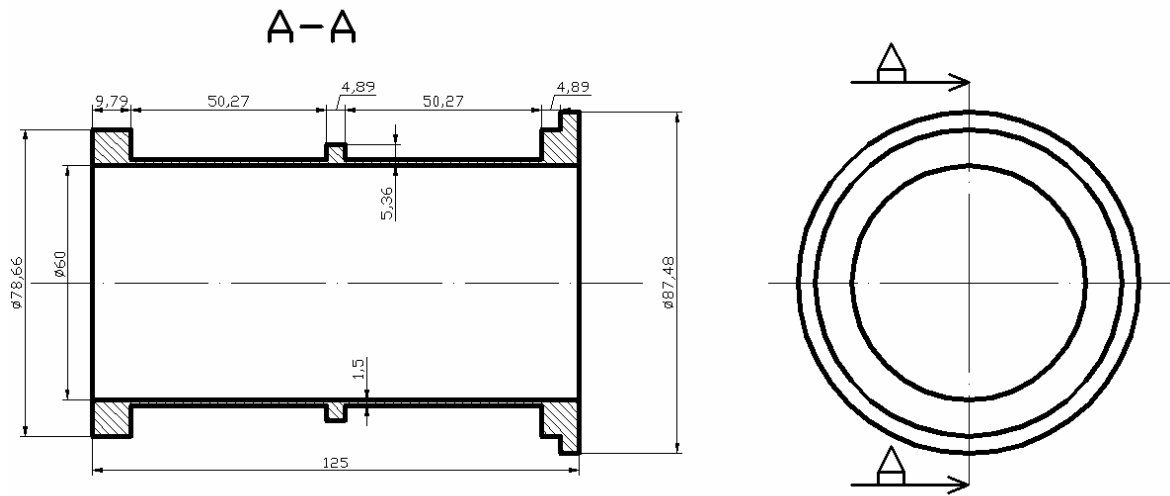


Fig. 7. Chuck collet

By running the program the device assembly drawing can be obtained (Fig 8) along with the drawings of the related elements.

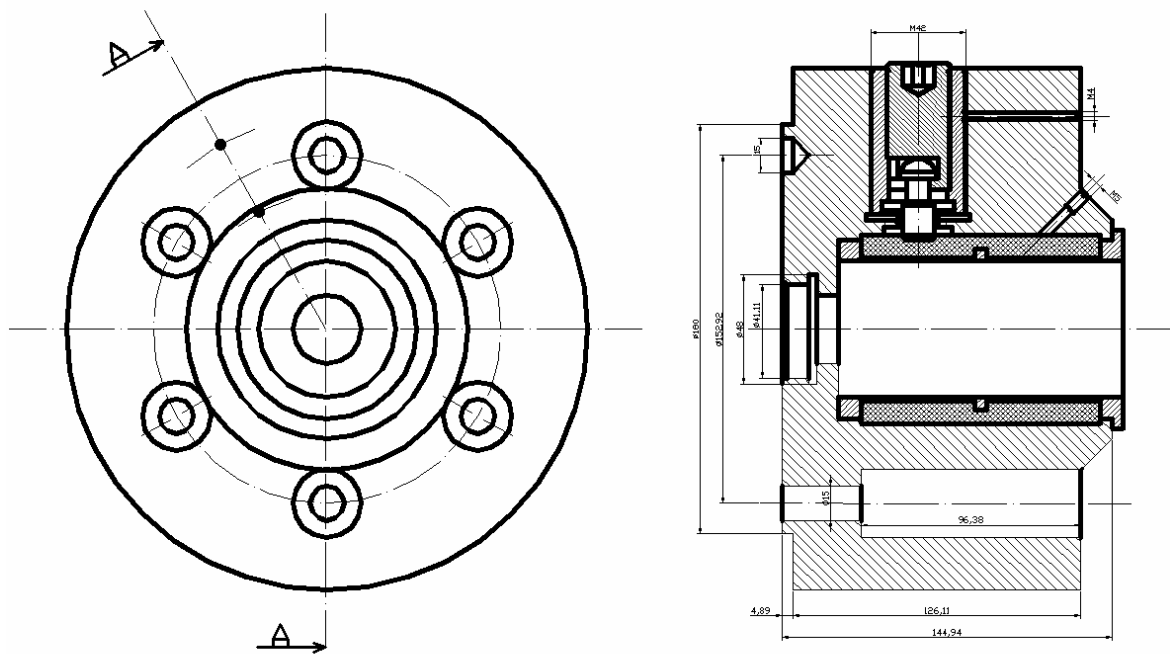


Fig. 8. Design of centering and fixes device

#### 4. Conclusions

Turning the design of hydro-plastic centering and fixing devices into an algorithm makes it possible to establish a number of stages which further make up a computation program; this facilitates entering the input data and obtaining the final piece assembly drawing.

The program designed is quite complex and enables the fast efficient sizing of the hydro-plastic centering devices for pieces of different dimensions which belong to the same category in terms of construction and geometry.

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#### Ein Algorithmus traf auf das Design der zentrierenden und regelvorrichtungen zu

##### Zusammenfassung

Das Gebrauchen der Hydro-plastikzentrierenden und regelvorrichtungen erhöht erheblich die Genauigkeit der mechanischen Fertigung sogar der milden materiellen Stücke. Das Papier beschreibt das Programm, das auf den Eingang Daten kann sortieren und liefert schließlich die Versammlung Zeichnung der Hydro-plastikvorrichtung gründete.

#### Algoritm pentru proiectarea dispozitivelor de centrare și fixare

##### Rezumat

Folosirea dispozitivelor de fixare și centrare cu hidroplast dau posibilitatea realizării unor prelucrări mecanice cu precizie ridicată chiar și pentru reperatele confecționate din materiale moi. În lucrare se prezintă un algoritm care permite ca pe baza datelor inițiale să se dimensioneze și în final să se obțină desenul de ansamblu al dispozitivului cu hidroplast